Normal Zone Creation and Propagation in YBCO Coated Conductors

J. Schwartz, F. Trillaud, H. Palanki,
U.P. Trociewitz, S.H. Thompson, and H.W. Weijers

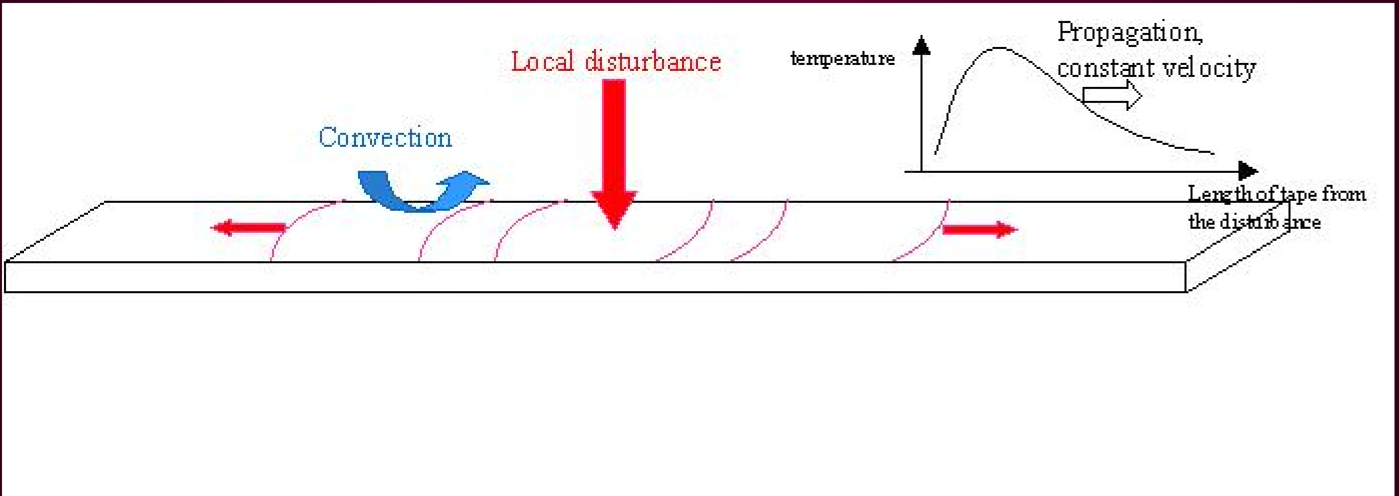
National High Magnetic Field Laboratory
Florida State University
January 22, 2003

Outline

- Definitions
- Experimental setup
- YBCO CC measurements
  - V-T-time-location
  - Fixed T_{start}~81 K, Various I/I_c
  - Quench Energy, Normal Zone Propagation
- Conclusions and Plans

Definitions

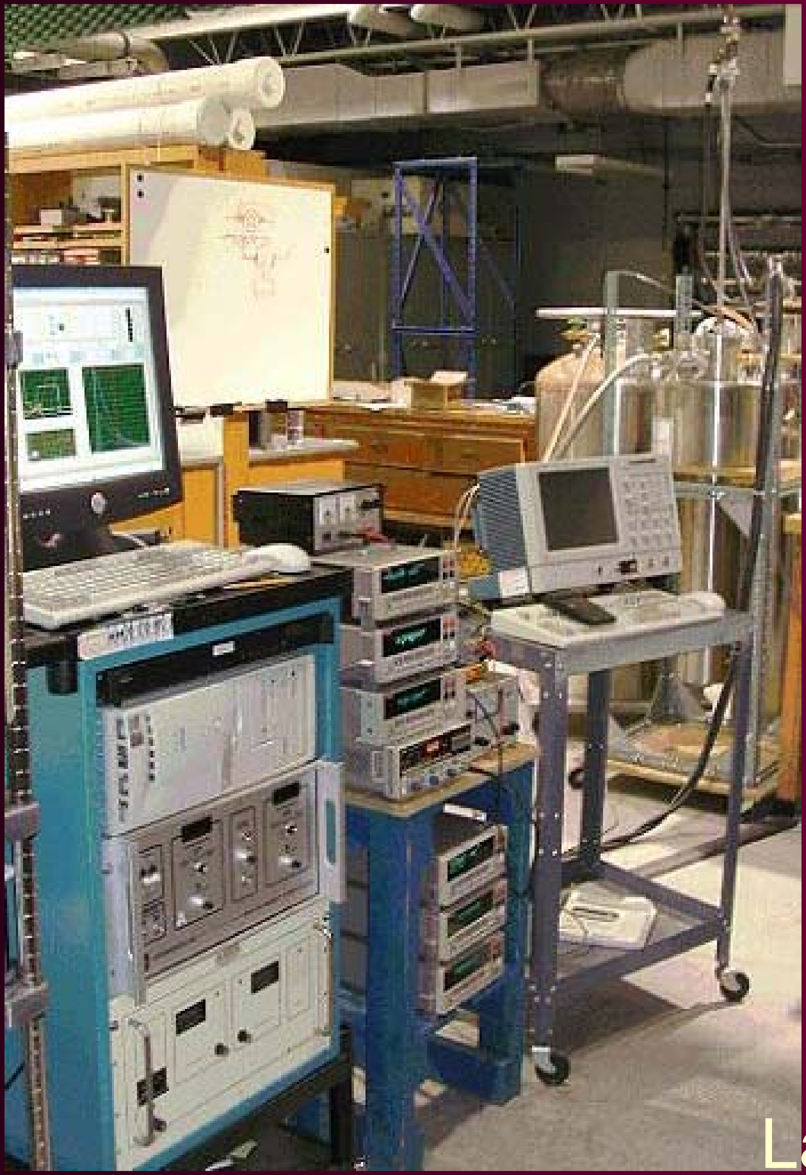
- **Local disturbance**: a localized temperature rise in the conductor; e.g. cracks in the insulations, friction between conductors, homogeneity, …
- **MQE**: minimum energy transferred to the conductor to generate a quench; can be different from the energy generated by the heater
- **NZPV:** speed at which normal region moves along the length of the conductor; related to the square root of the ratio between the heat generation and cooling



Experimental Details

- AMSC YBCO, 50 A@77 K (circa Fall 01)
- Experimental procedures
  - Sample mounted and instrumented with multiple voltage taps, embedded Cernox temperature sensors
  - Heat pulse supplied by NiCr wire driven by a power supply and pulse generator
  - Sample cooled by N_2 gas convection (~81-83 K)
  - Heat pulse amplitude or duration increased until quench occurs (vs. I/I_c)

Experimental Setup



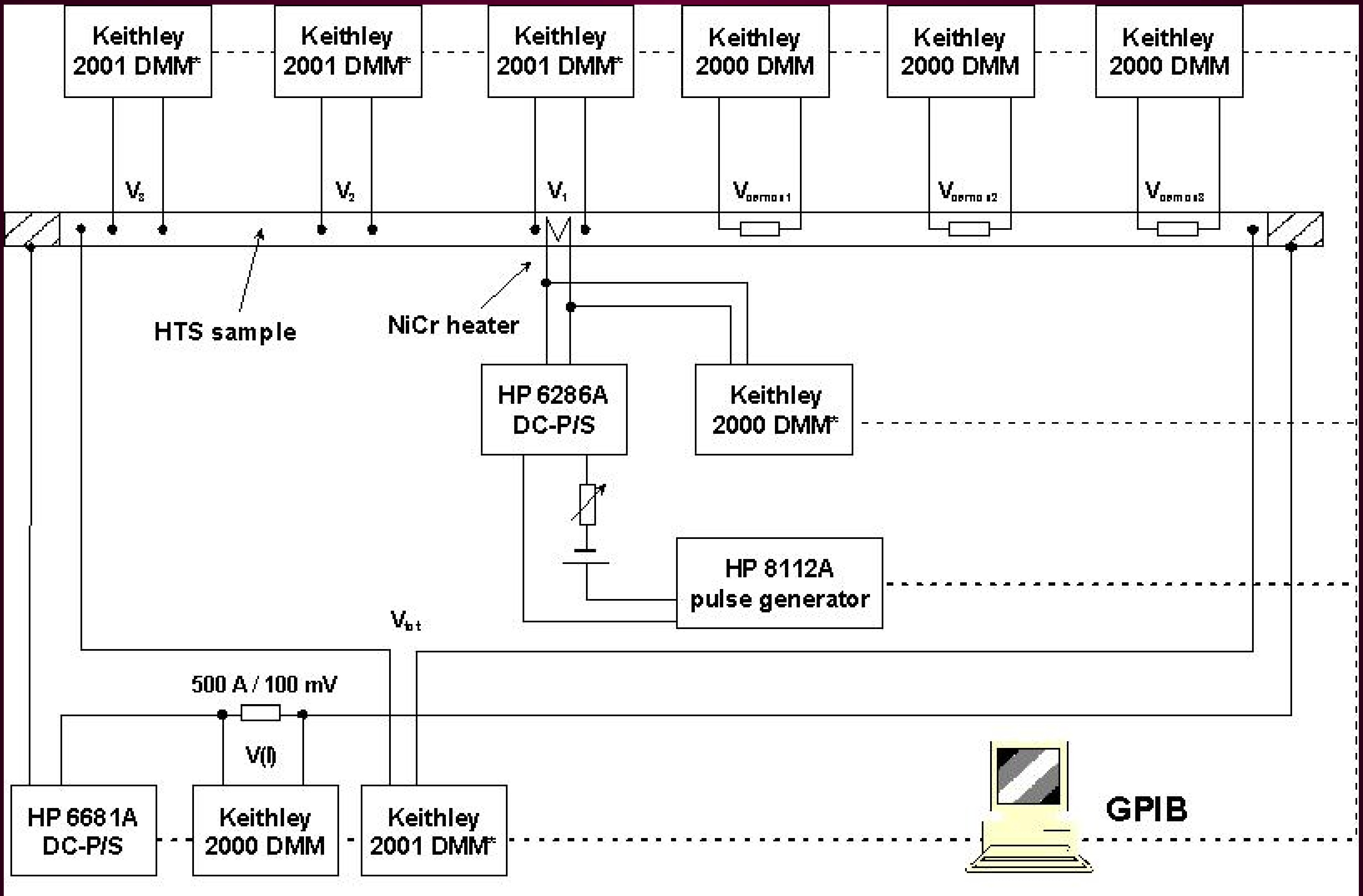
Cryostat with LN_2 jacket, experimental chamber filled with N_2 gas

Array of Keithley DMMs, pulse generator, PS for heater

DAQ computer and power supplies

LabView controls all instruments

Wiring Schematic for Quench Experiments

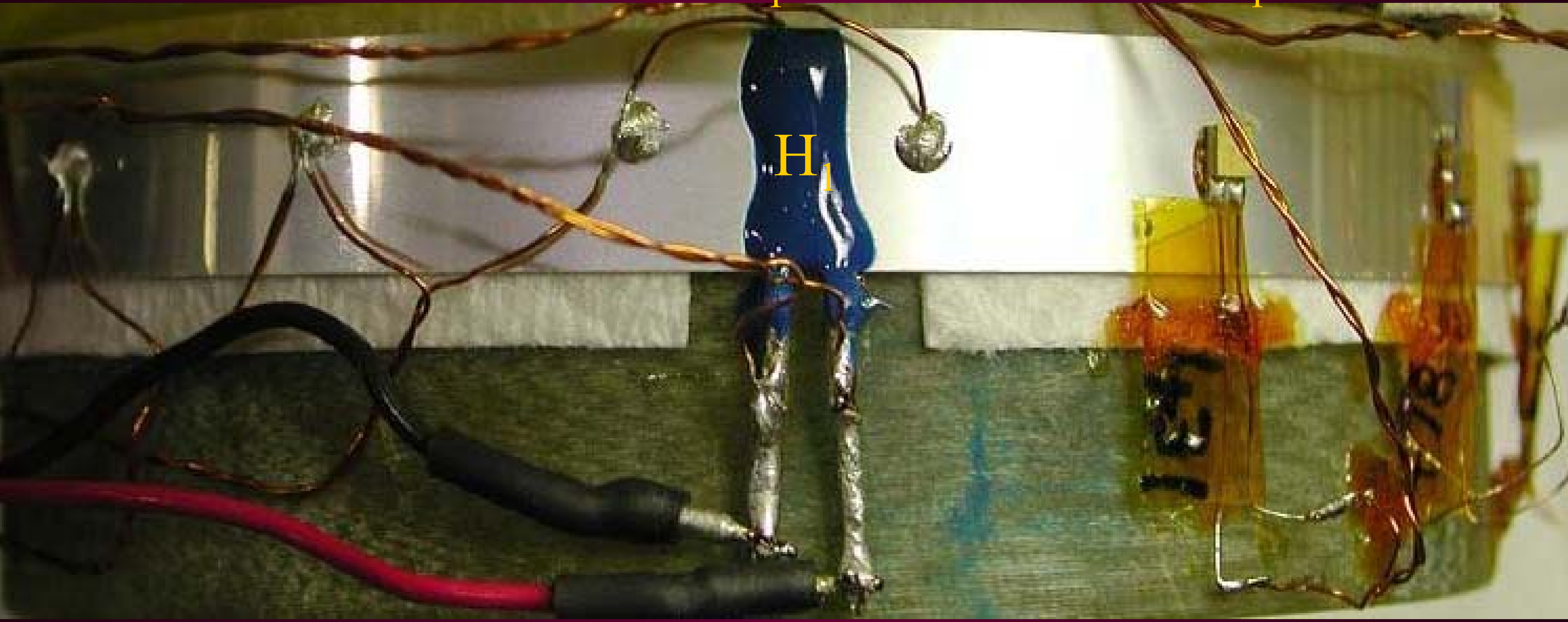


*set on buffer read for increased speed/resolution

YBCO CC mounted

V_1 covers heated zone (H_1), C_1 mirrors V_2, C_2 mirrors V_3, etc.

V_3 V_2 V_1 C_1 C_2



paper to accommodate thermal contraction
and reduce conduction to G10

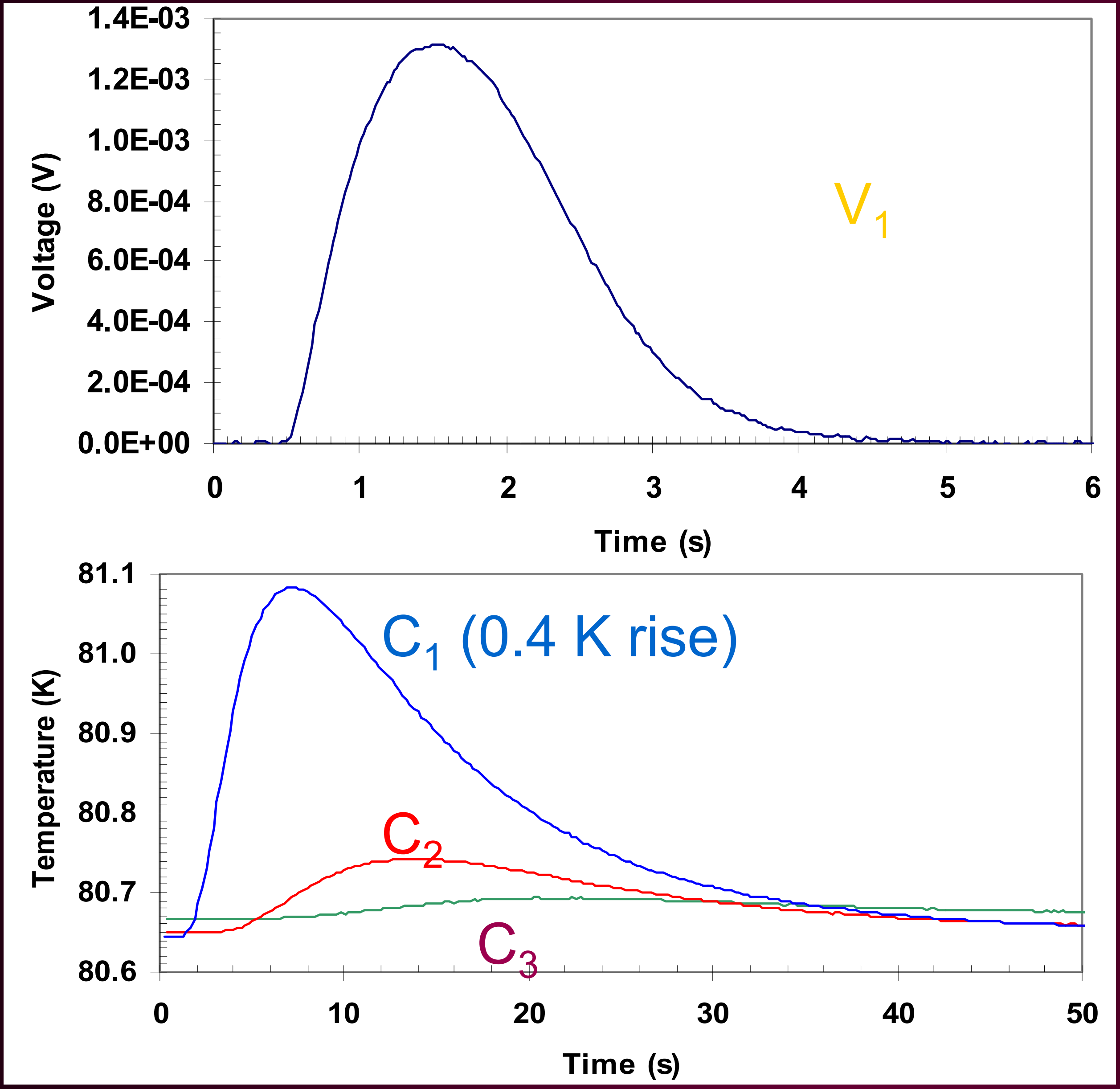
NiCr heater loop on YBCO CC

Area under heater:
~ 23 mm^2, 3.2 mm^3

"Hot zone" after pulse
~40 mm^2, 5.6 mm^3

every 0.8 mm of = 1mm^3

Voltage-time I=19 A; I_c=22 A



E_{pulse}= 235 mJ < MQE

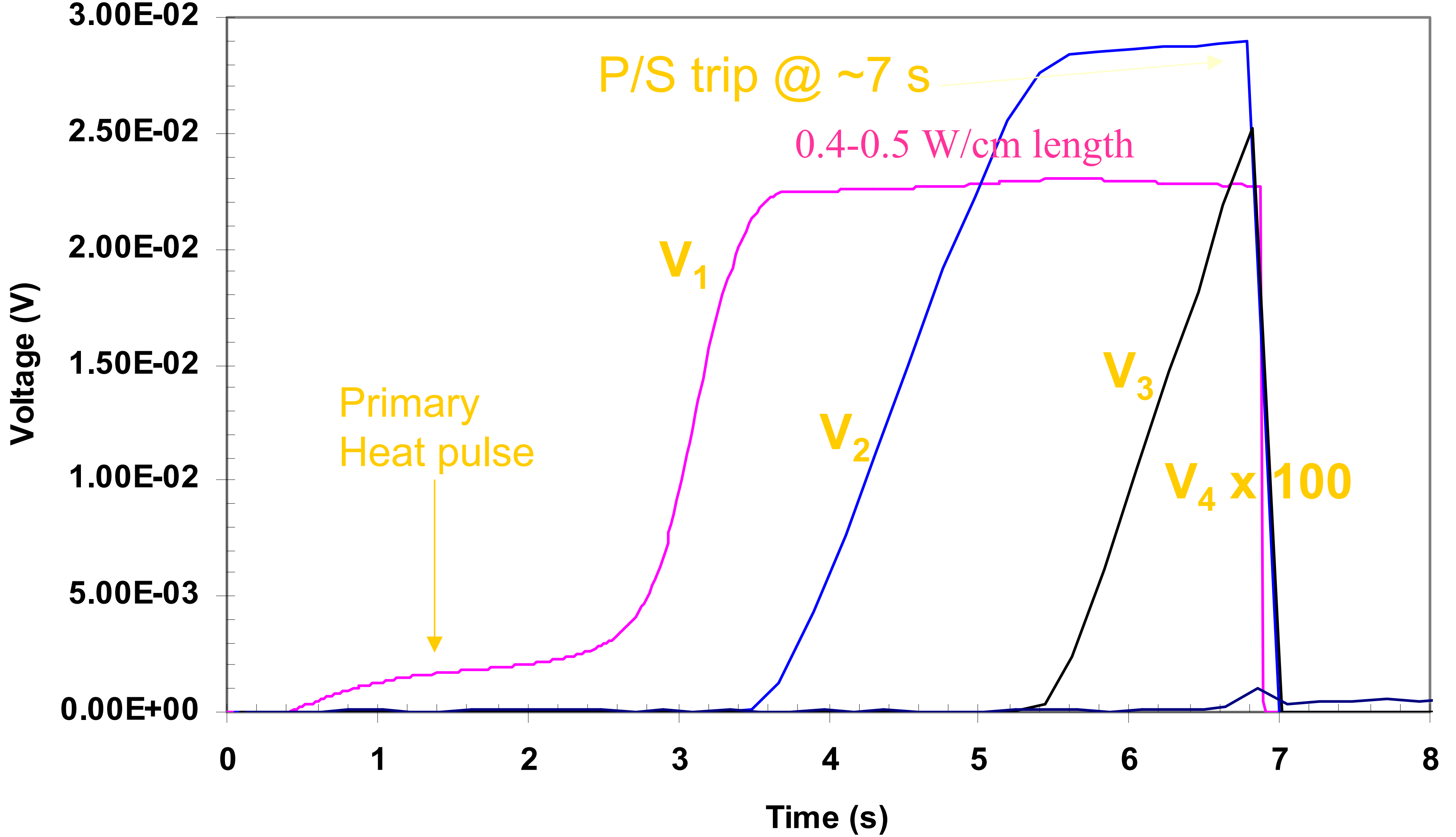
T=80.6 K

J_e=18 A/mm2

Voltage-time-location during quench

I = 19 A

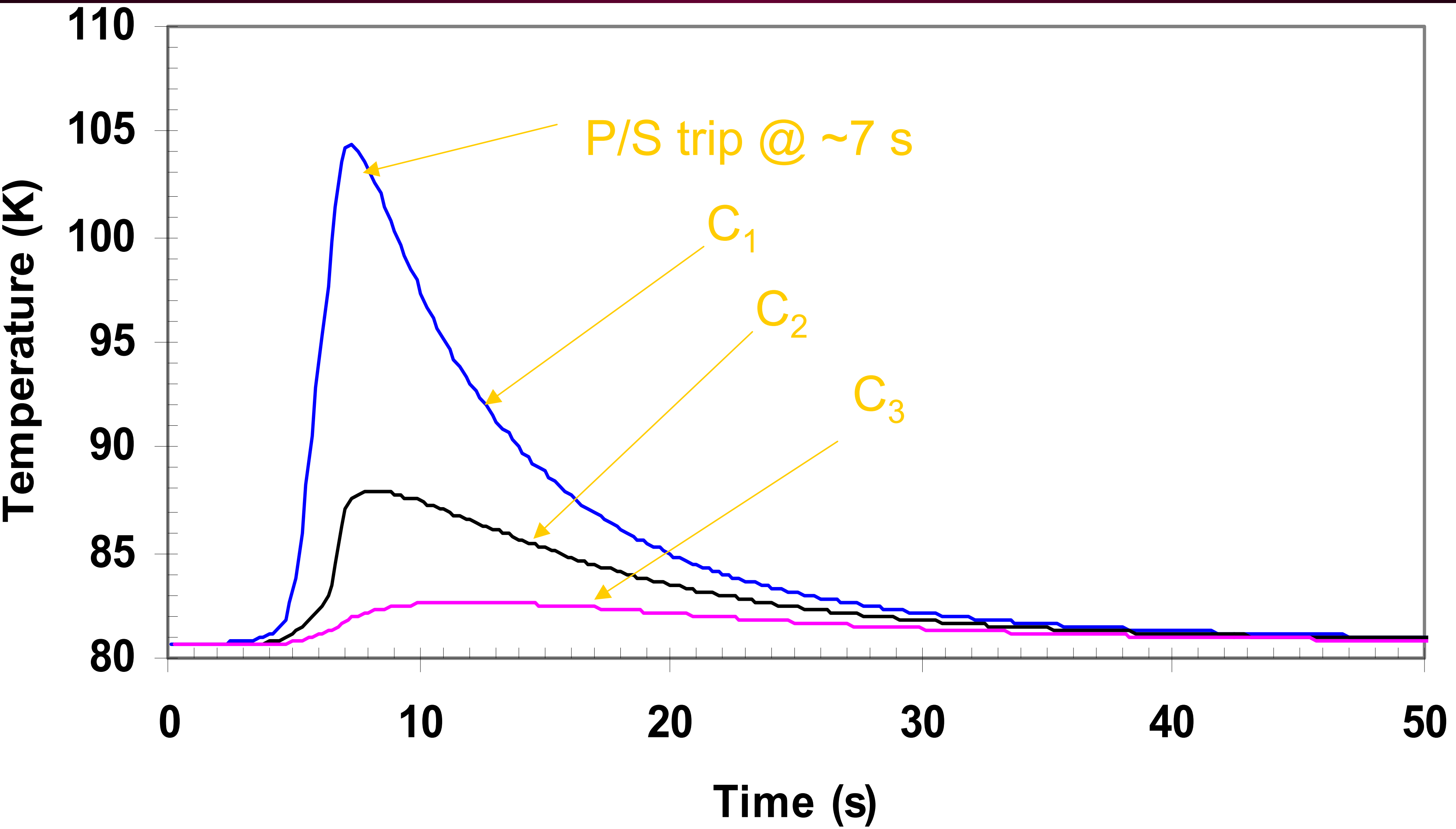
$E_{pulse} \geq MQE$
T=80.6 K



Temperature-time-location during quench

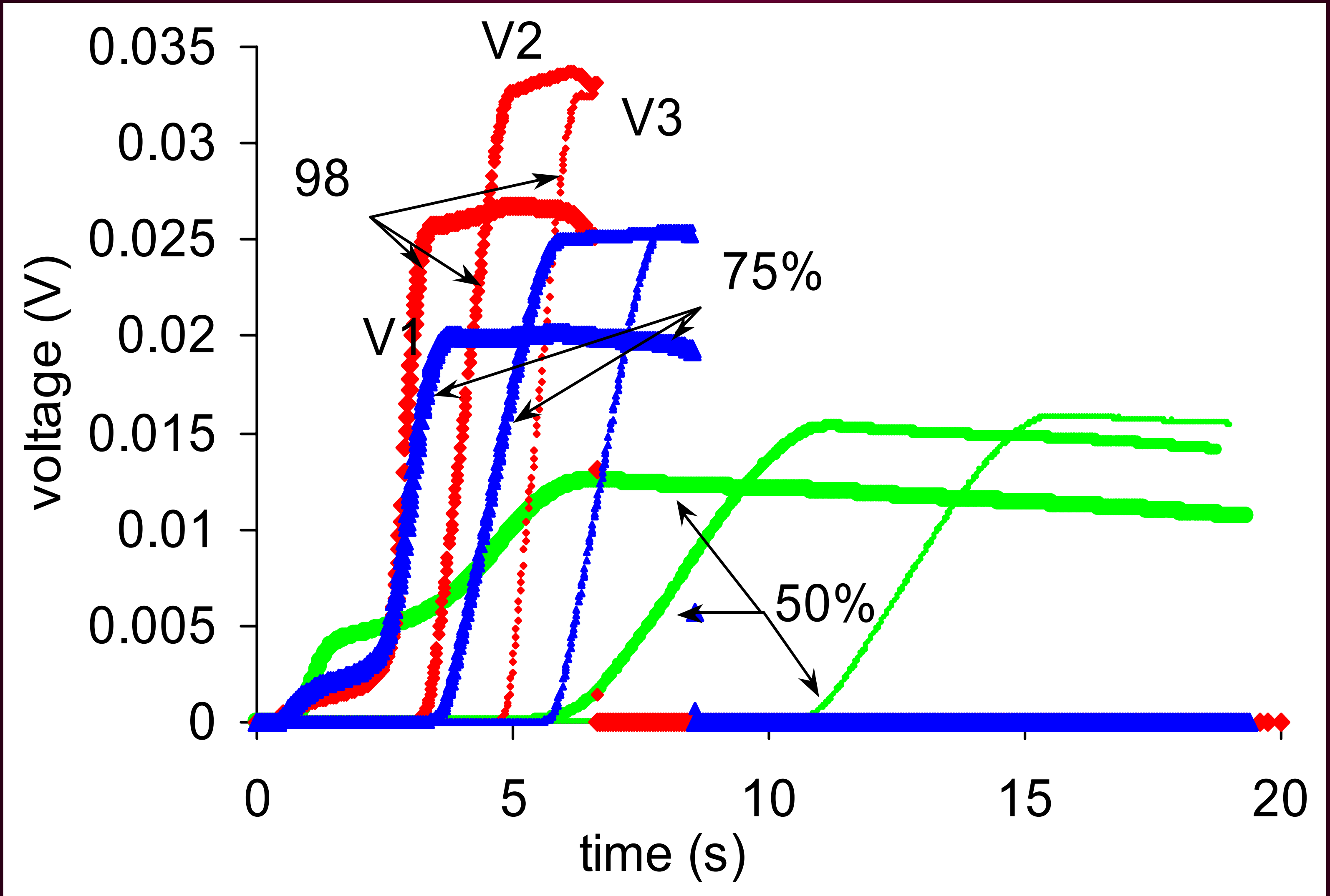
I = 19 A

$E_{pulse} \geq MQE$
T=80.6 K

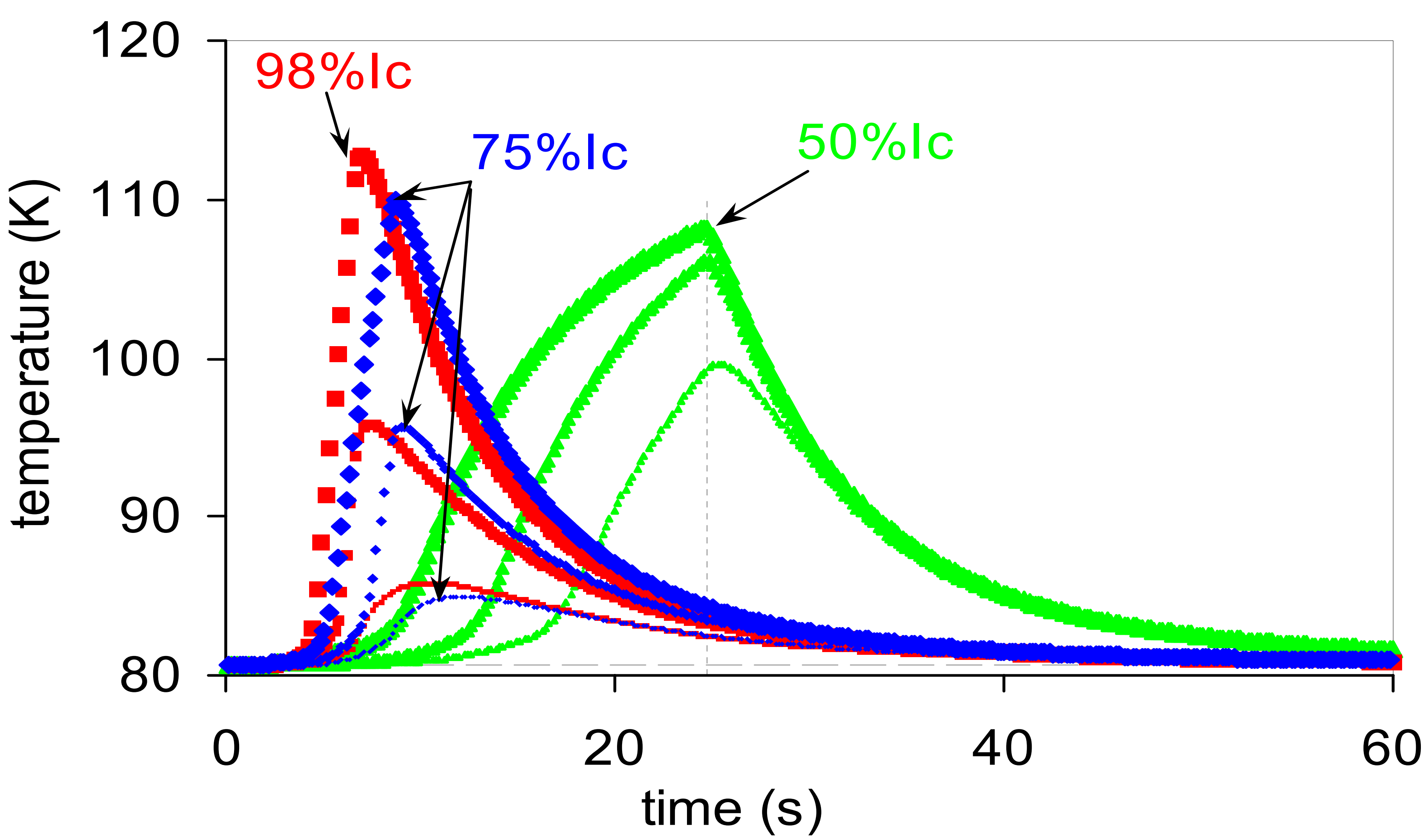


Voltage v. time @ MQE, various $I<I_c$

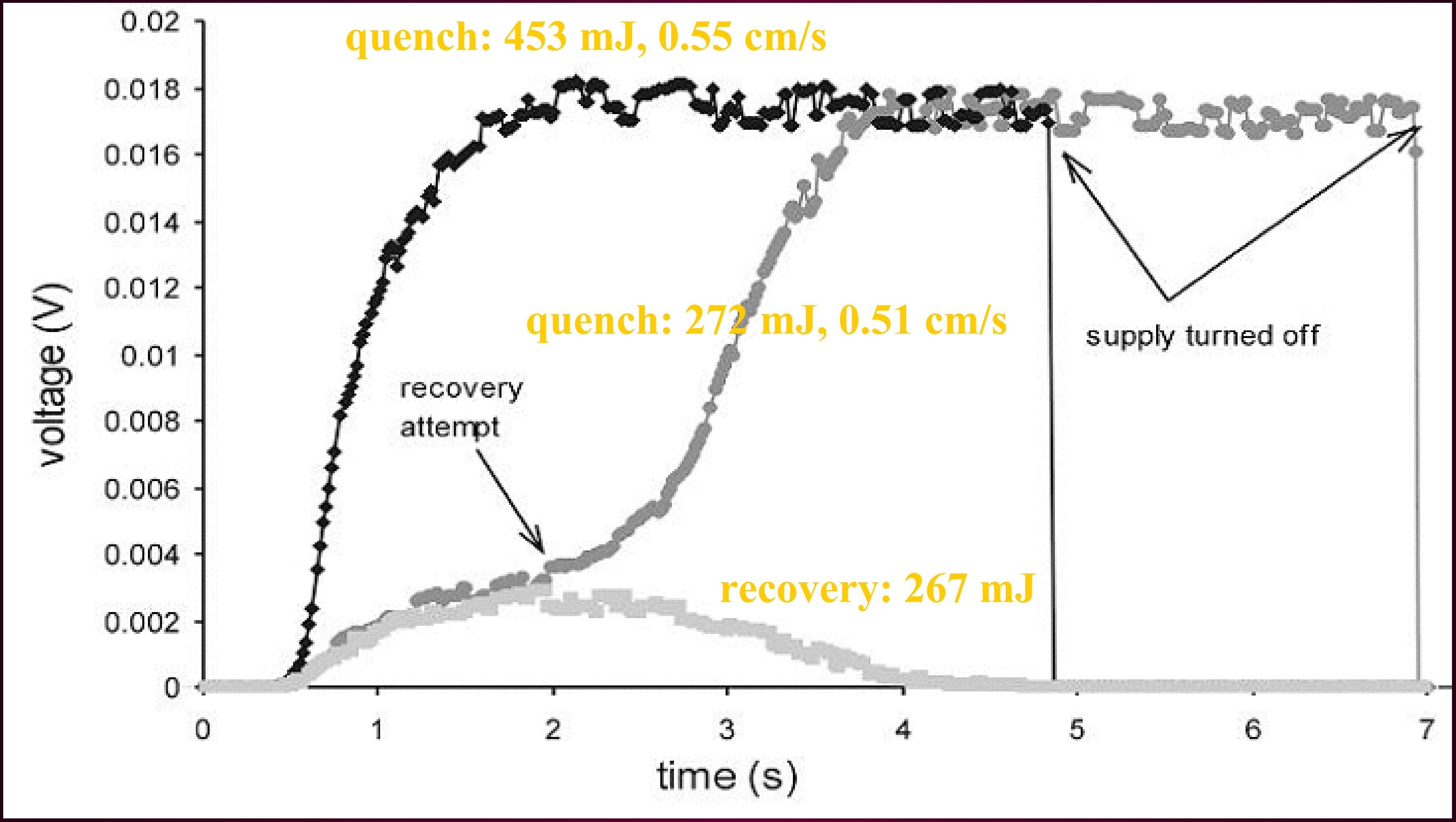
50%,75%,98% I_c; vary heater pulse duration; T=80.6 K; I_c=22.5 A

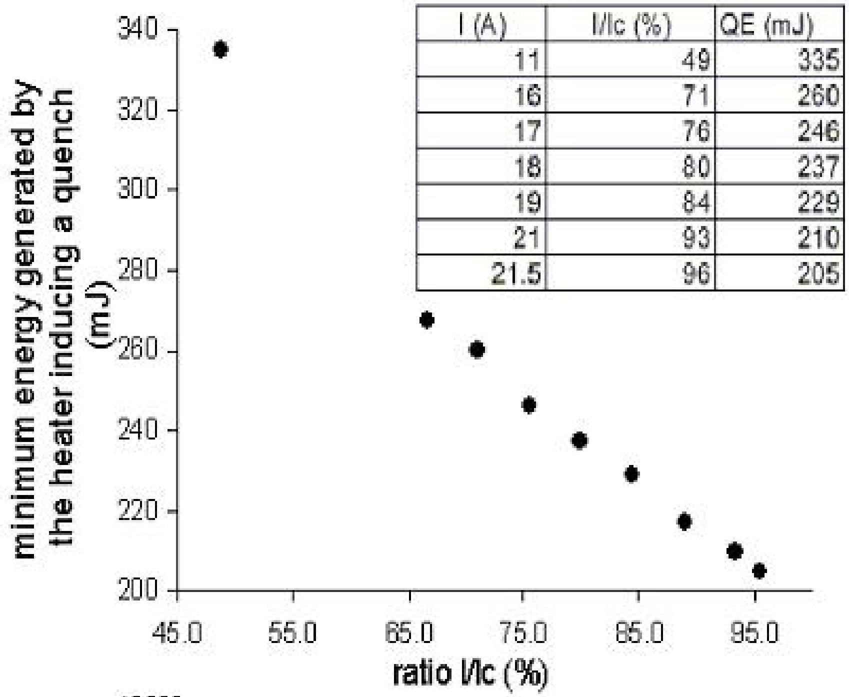


Temperature v. time @ MQE, various $I<I_c$

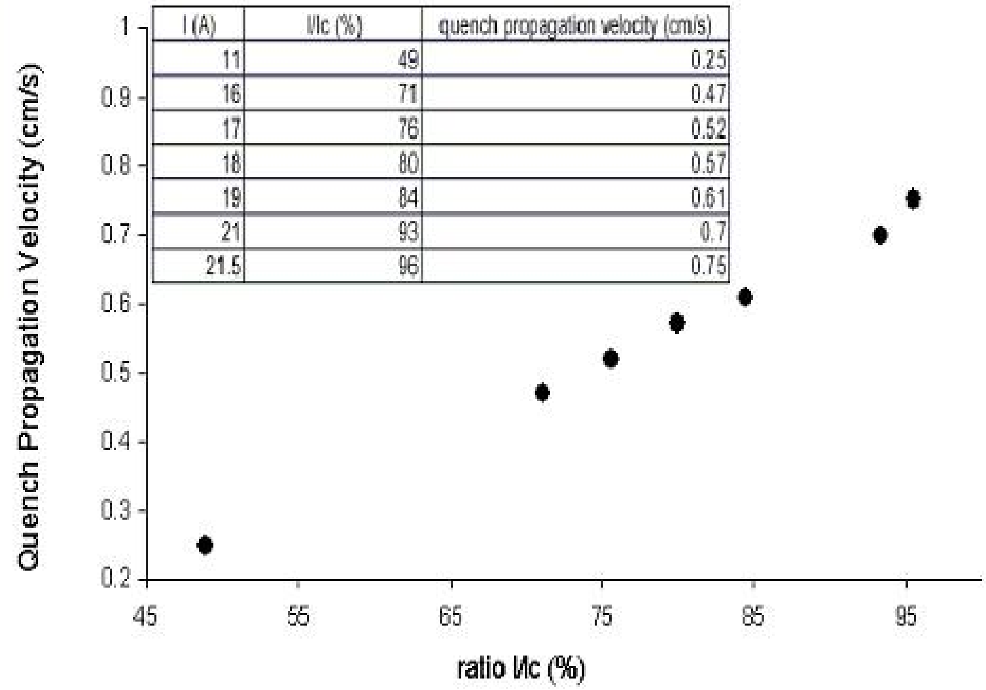


Above and below MQE, $I=0.75I_c=17$ A

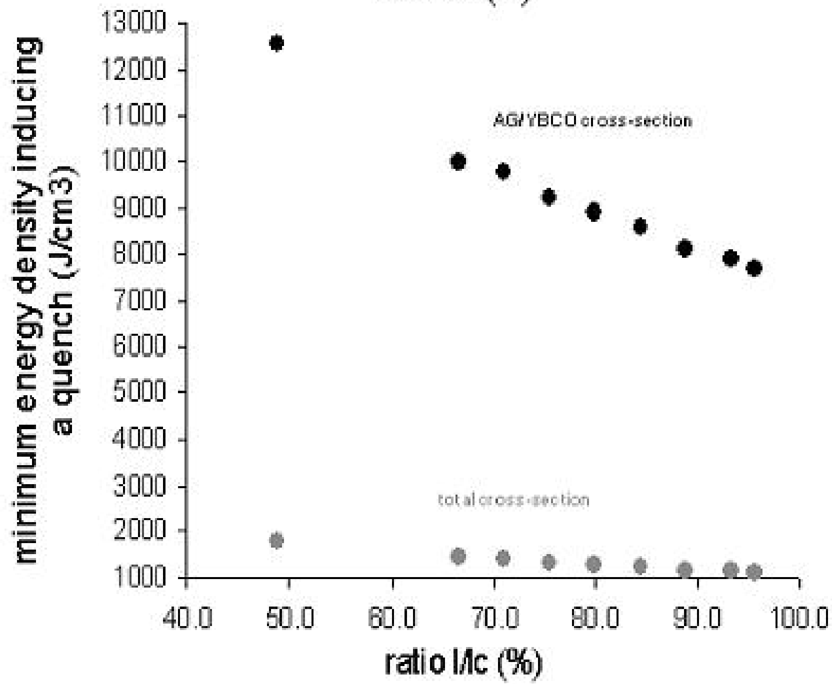


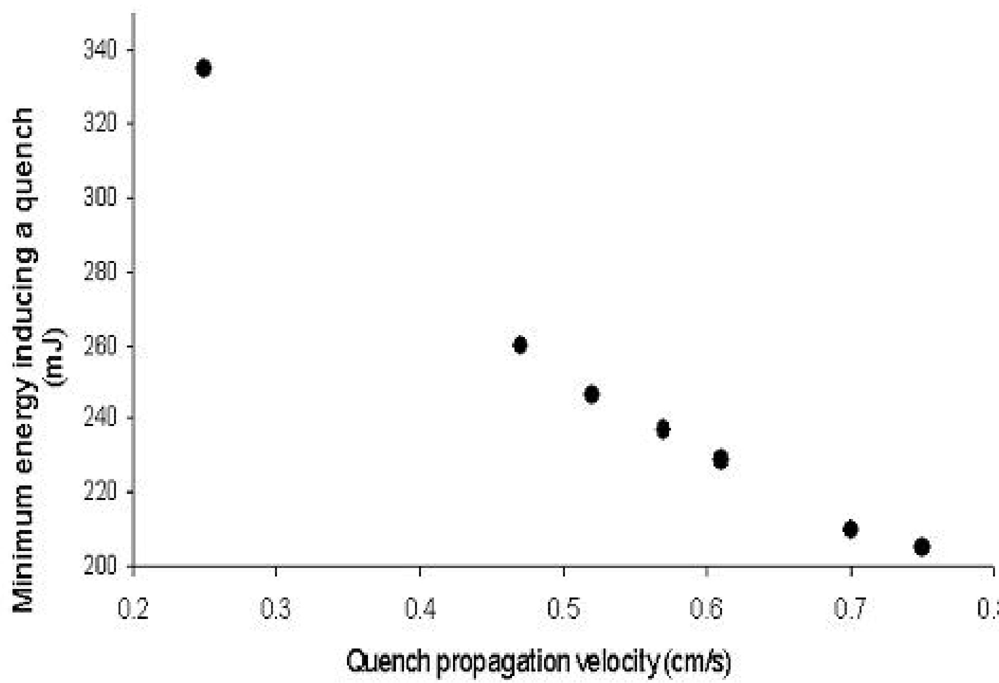


I (A)	I/Ic (%)	QE (mJ)
11	49	335
16	71	260
17	76	246
18	80	237
19	84	229
21	93	210
21.5	96	205



I (A)	I/Ic (%)	quench propagation velocity (cm/s)
11	49	0.25
16	71	0.47
17	76	0.52
18	80	0.57
19	84	0.61
21	93	0.7
21.5	96	0.75





Conclusions

- MQE and NZP can be measured for localized heat loads
- Friendly quenches; no sample burn-out or degradation after ~10^2 heat pulses
- NZPV slow at 81 K
  - expected to increase w/ higher J_c
  - & lower temperature,
  - & more Ag,
  - or conducting substrate
  - …

Plans

FSU

- Experimental modifications
  - Heater
  - Voltage taps on Ni side (current sharing)
  - Relocate Cernox sensors adjacent to the voltage taps
- Experimental plans
  - Heat capacity of NiCr & Stycast; benchmark at I=0 A (thermal diffusion)
  - Lower temperatures & vacuum with cryocooler; vary J_c via magnetic field
  - Determine max hot-spot temperature, temperature gradient → critical parameter for design of protection system
  - Vary conductor architectures (*e.g.*, Ag thickness)

MIT

- Stability enhancement with solid N2
- Quench/recovery experiments with bath or forced-flow cooling
- Detection of “Hot Spots” with Acoustic Emission techniques